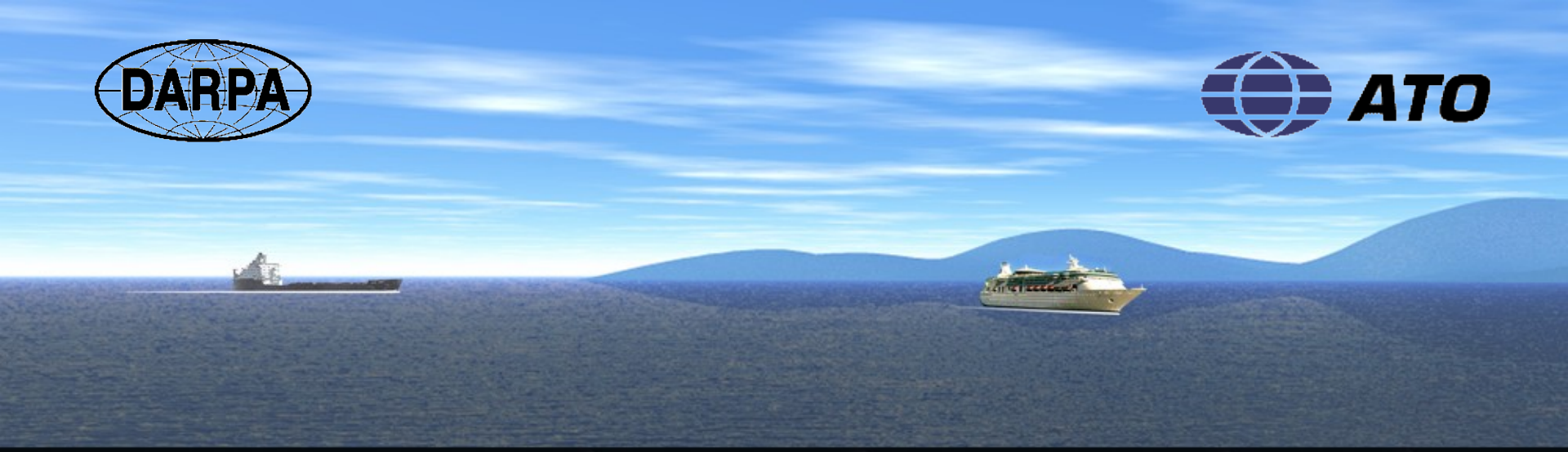
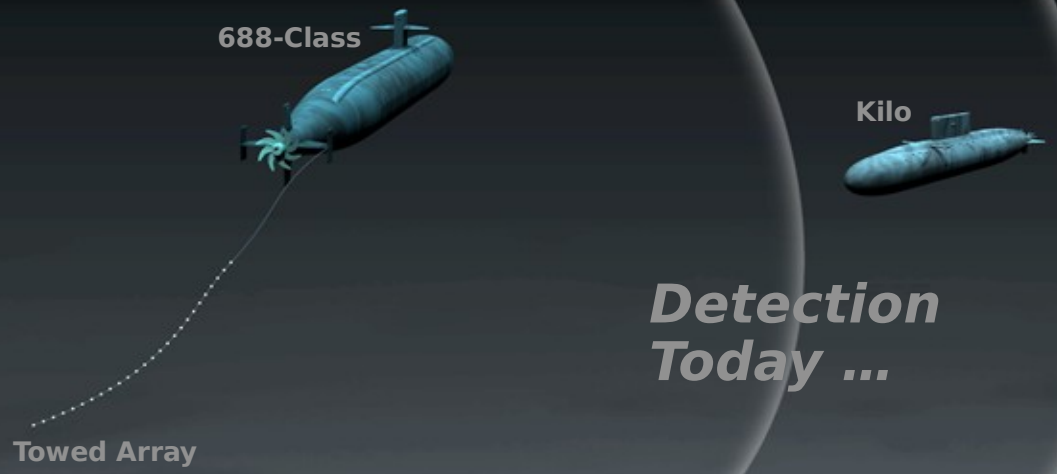


Goals & Technical Objectives

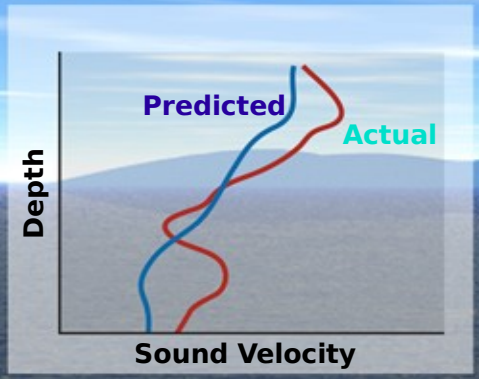


Detection Today …

… Tactical Control

Dr. Thomas J. Green, Jr.
Program Manager
27 October 2000

Littoral Anti-Submarine Warfare



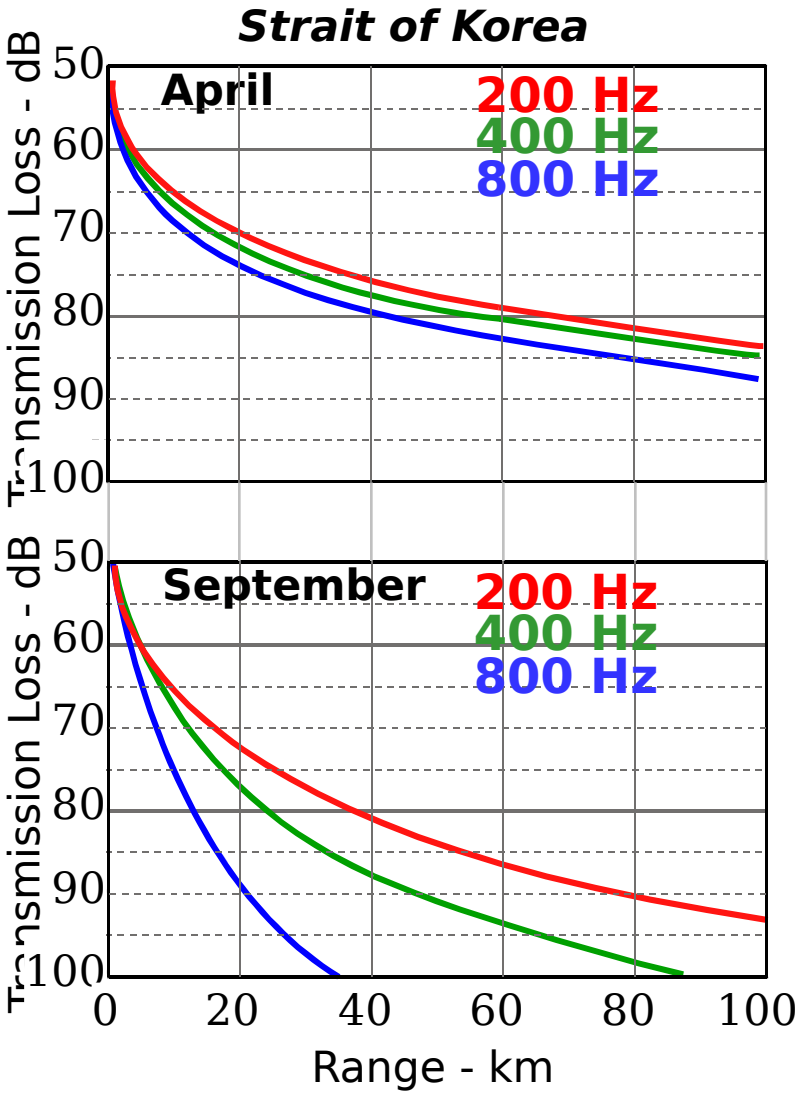
Forward-deployed tactical sonar systems must be robust to:

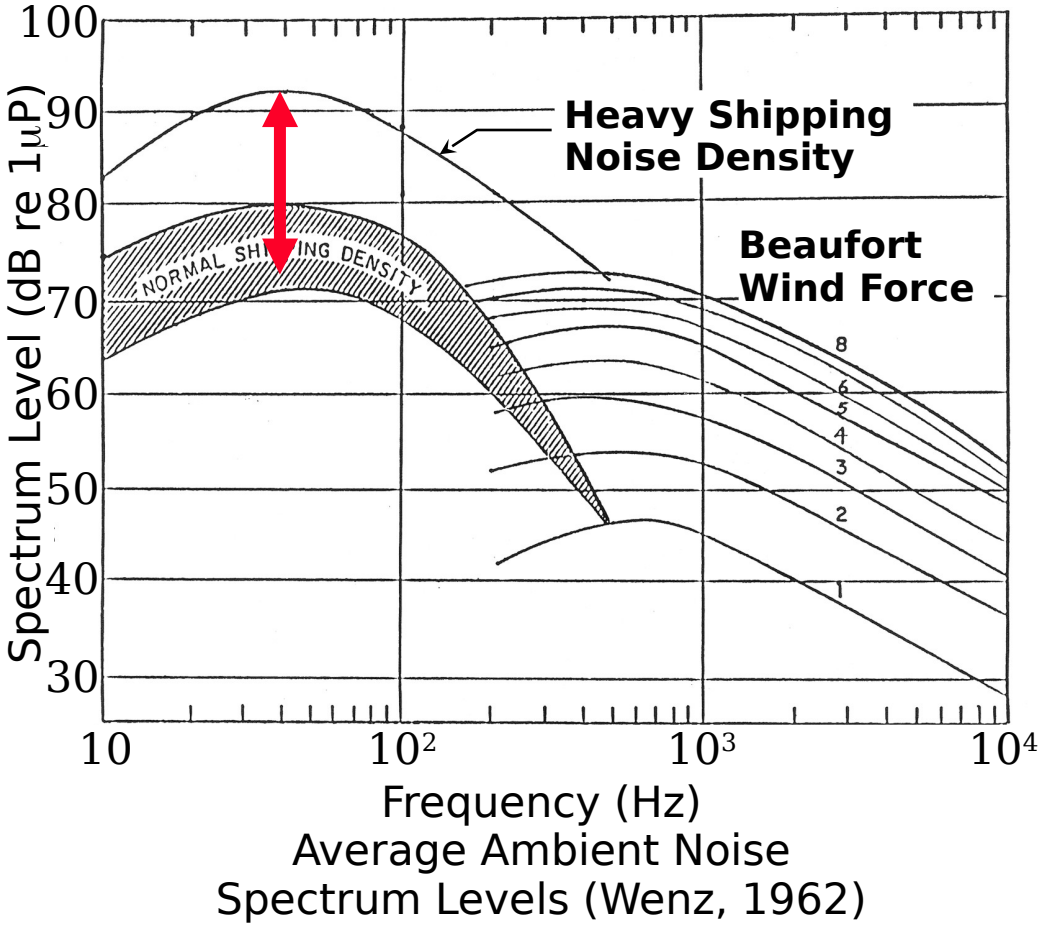
- Progressively quieter D/E submarines
- Shallow-water multi-path propagation
- Loud surface discretes
- Challenging source-receiver dynamics
- Counter-detection

Robust Passive Sonar

- Mobile arrays
- Adaptive Matched-Field Processing
- Discrete surface noise suppression
- Motion compensation

Littoral ASW Implications

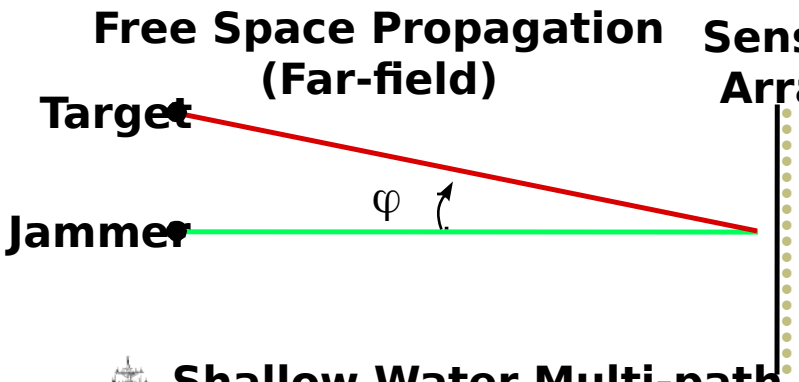


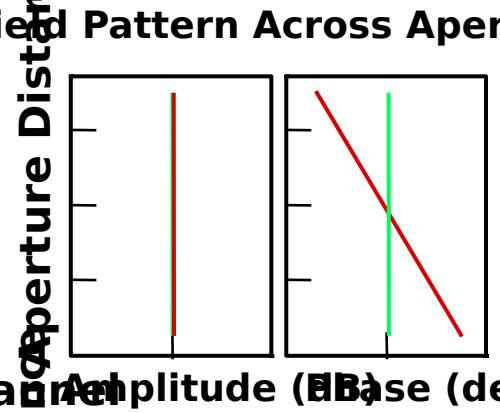


Average Ambient Noise
Spectrum Levels (Wenz, 1962)

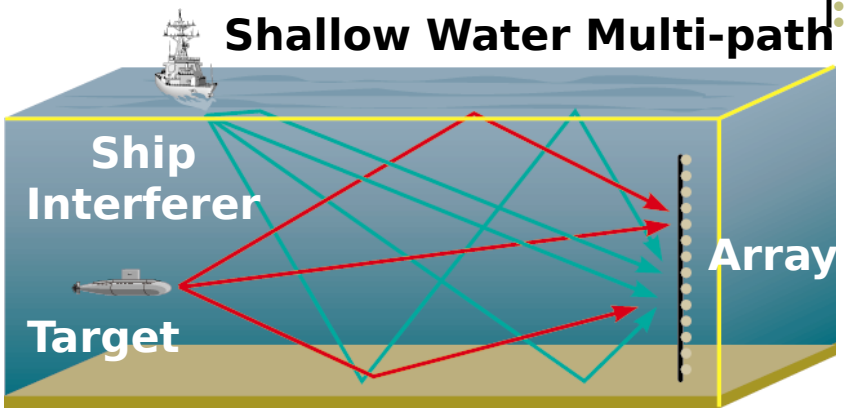
SE = SL – TL - AN + AG – RD

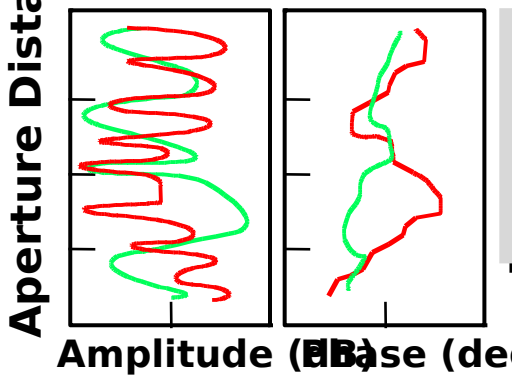
Matched Field Processing (MFP)





Source Location
⇒ **Phase Slope Across Aperture**



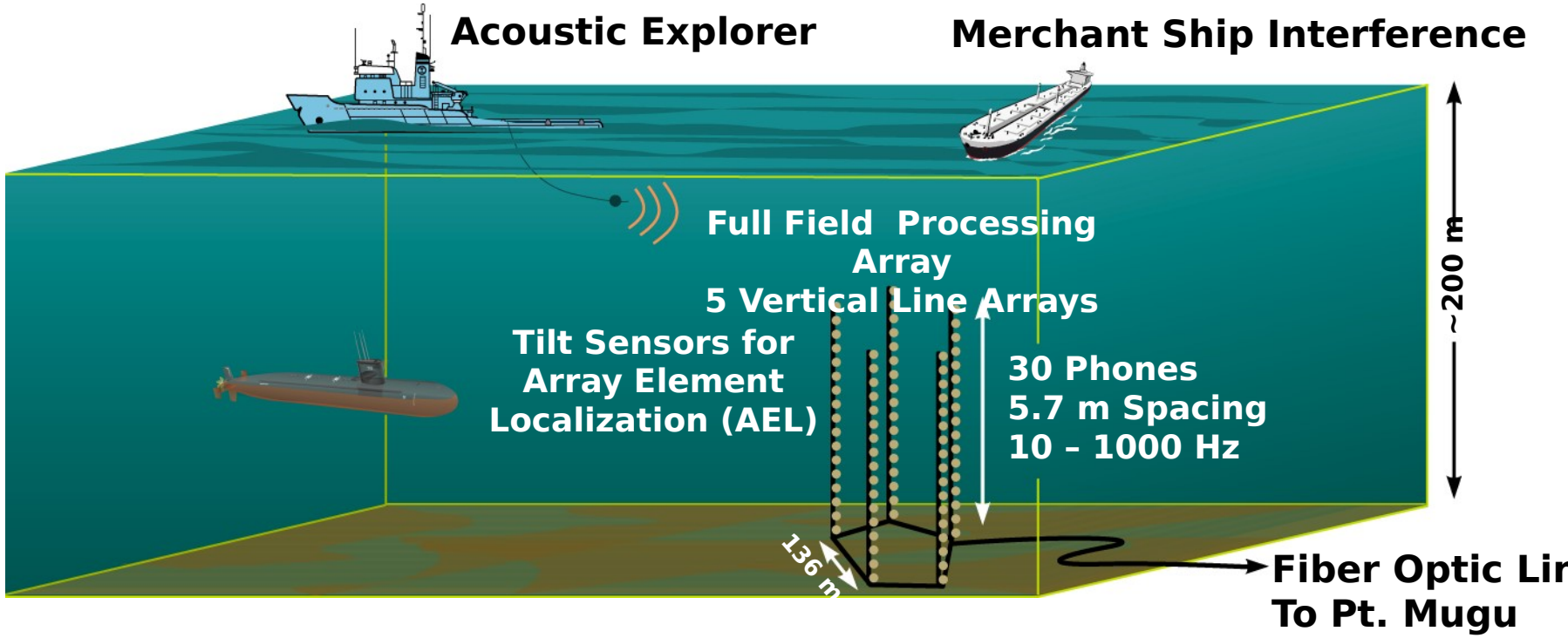


Source Location
⇒ **Deterministic Phase, Amplitude Across Aperture**

- **Steering vector derived from propagation model**
- **Exploits channel multi-path for detection/localization**
- **Adaptivity rejects interference and reduces sidelobes**

- **Main issues**
  - **Robustness to environmental uncertainty**
  - **Estimating scene statistics with limited snapshots**

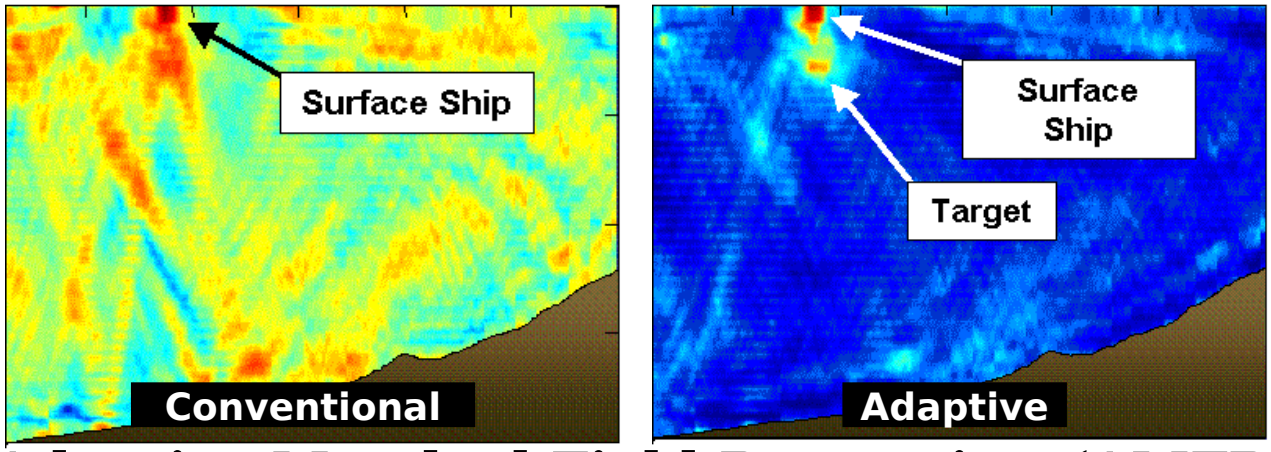
Santa Barbara Channel Experiment (SBCX)



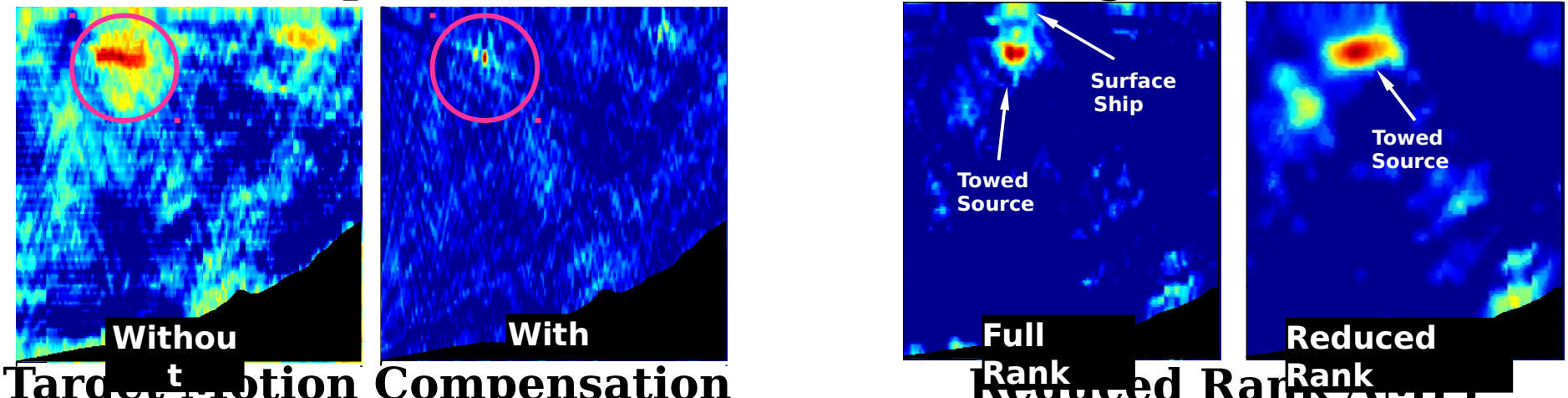
Objectives:

- Establish fundamental limits to signal and noise gains with Adaptive Matched Field Processing (AMFP) for passive broadband detection, localization, and classification
- Extrapolate measured performance to other threats, environments, and sensors of interest

SBCX Results



Adaptive Matched Field Processing (AMFP)



Target Motion Compensation **Reduced Rank AMFP**

Adaptive techniques show promise for depth discrimination with fixed receiver geometries

Robust Passive Sonar

Goal

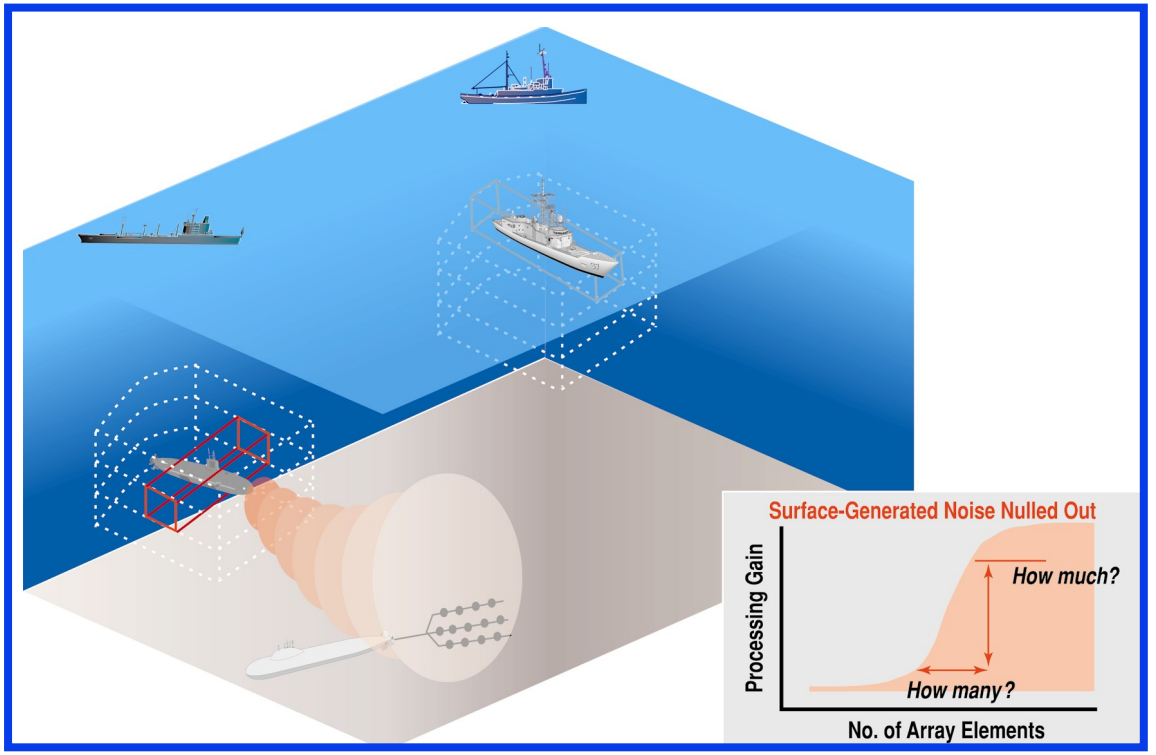
Achieve greater than 10 dB of low-frequency noise reduction in high traffic coastal areas

Approach

- **"Clean sheet of paper" tactical sonar algorithm architecture**
- **Adaptive processing to suppress shipping noise**
- **Data-driven development**
- **At-sea experiments with existing and emerging mobile arrays**

Products

- **Algorithms**
- **Array concepts**
- **Performance results**



Remove discrete surface shipping to see what is left!

Canonical RPS Problem

- **Real-time search of 2500 km² operational area (if supported by the propagation environment)**
  - **Primary mission: Quiet threat search**
  - **Secondary mission: Surface scene management, especially in support of primary mission**
- **Shallow-water propagation environment**
  - **Multiple bottom interactions**
- **Noise field dominated by discrete surface interference**
- **Mobile multi-line towed-array sensor instrumented to support array shape estimation**
- **Necessary for tactical control**
  - **Array processing during maneuvers**
  - **Forward-sector processing**

Objective: Develop end-to-end processing architecture to solve the canonical problem

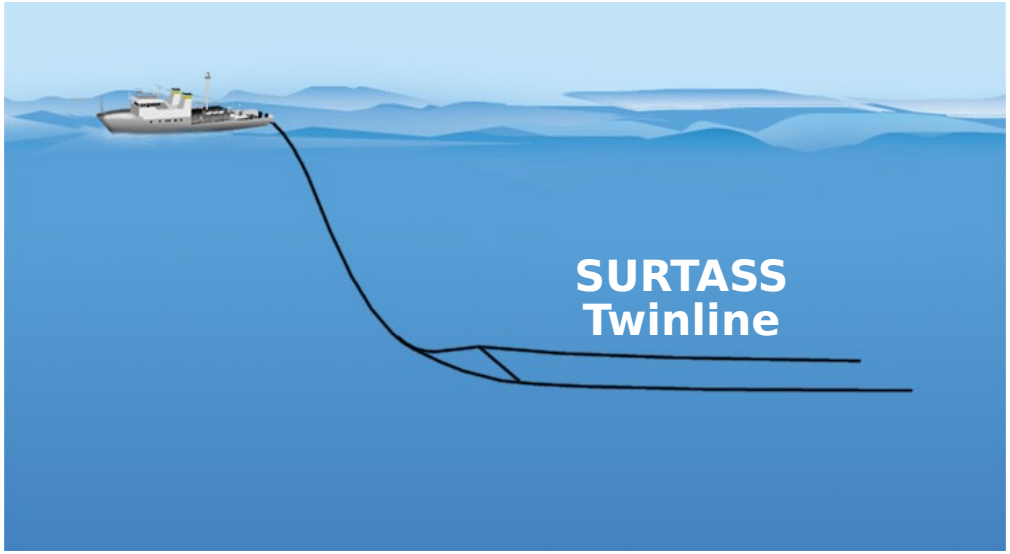
System Challenges

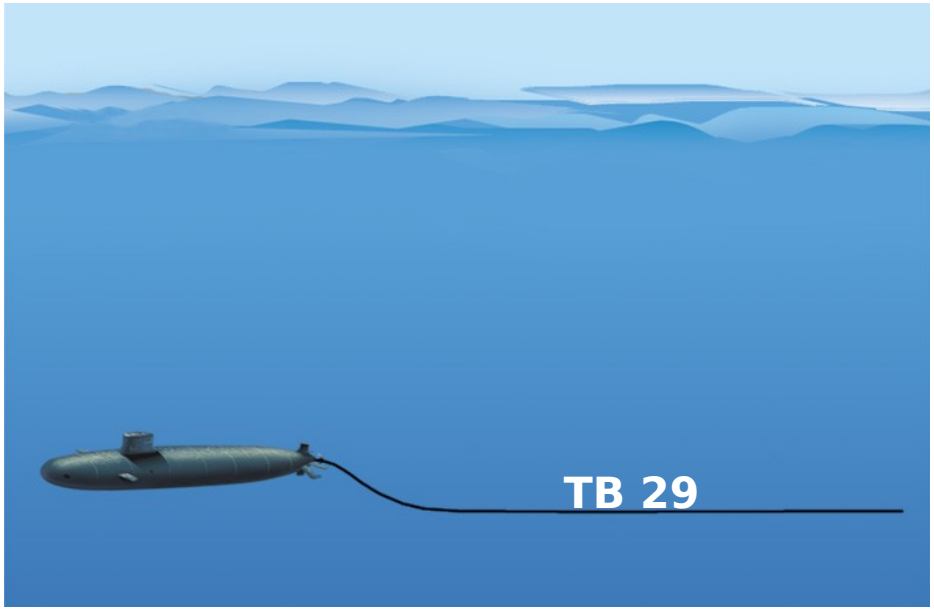
1) Adaptive suppression of loud structured surface interference given
   - Multi-path shallow-water environments
   - Significant source-receiver dynamics and other sources of system non-stationarity
2) Target detection in forward-sector in the presence of own ship noise interference
3) High array gain during maneuvers or when the sensor departs from nominal array geometries
4) Rapid high-dimensional threat search with minimal manning
5) In situ environmental calibration with sufficient fidelity to meet the other challenges

Development Approach

Technical Activities

- System architecture trades
- Adaptive algorithm and system development
- Performance assessment
- At-sea demonstration





Data Sources

- Appropriate existing data sets
- Three at-sea experiments with mobile single / multi-line arrays

Candidate Arrays

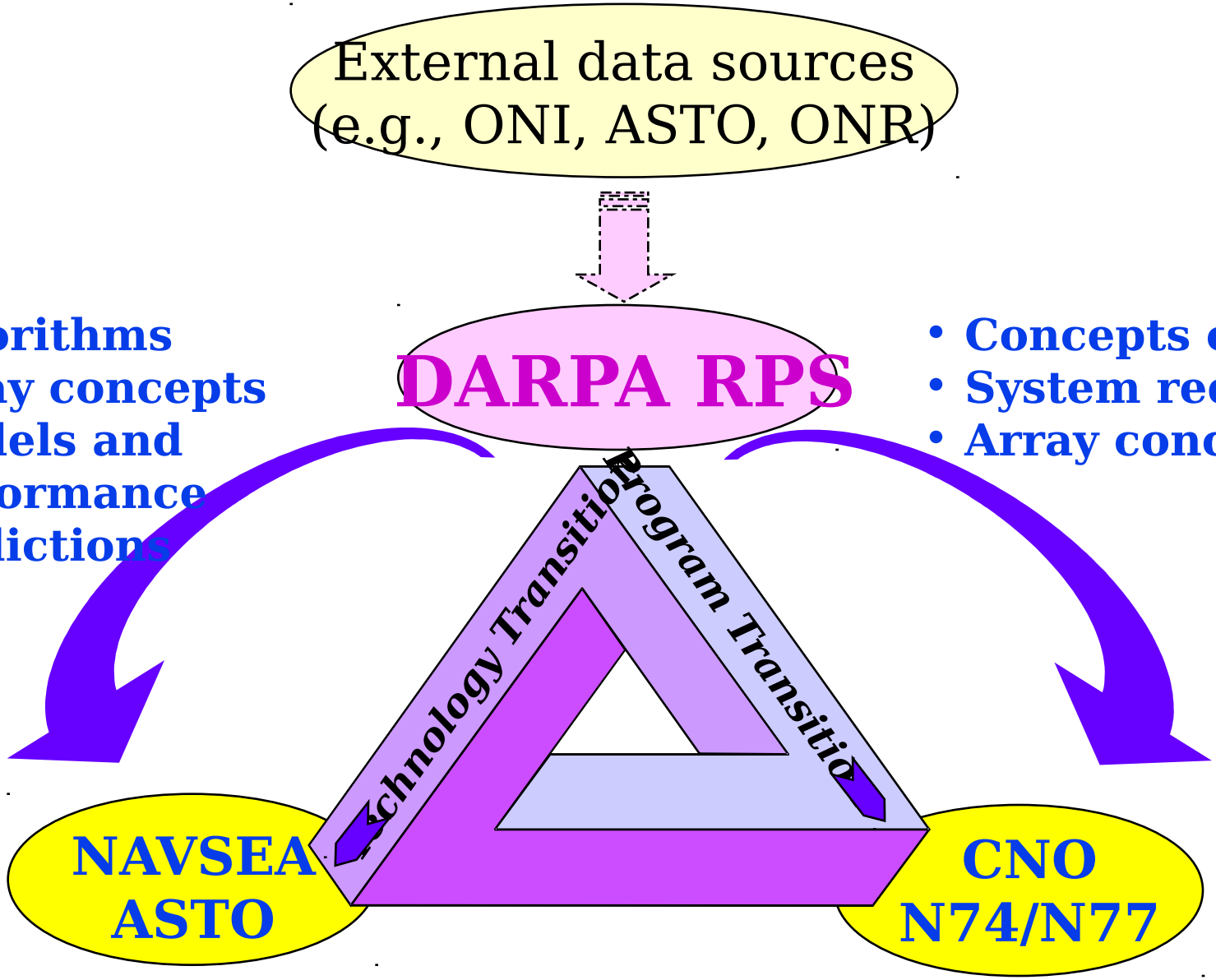
- TB-29
- SURTASS Twin-line
- Others

Technology Areas

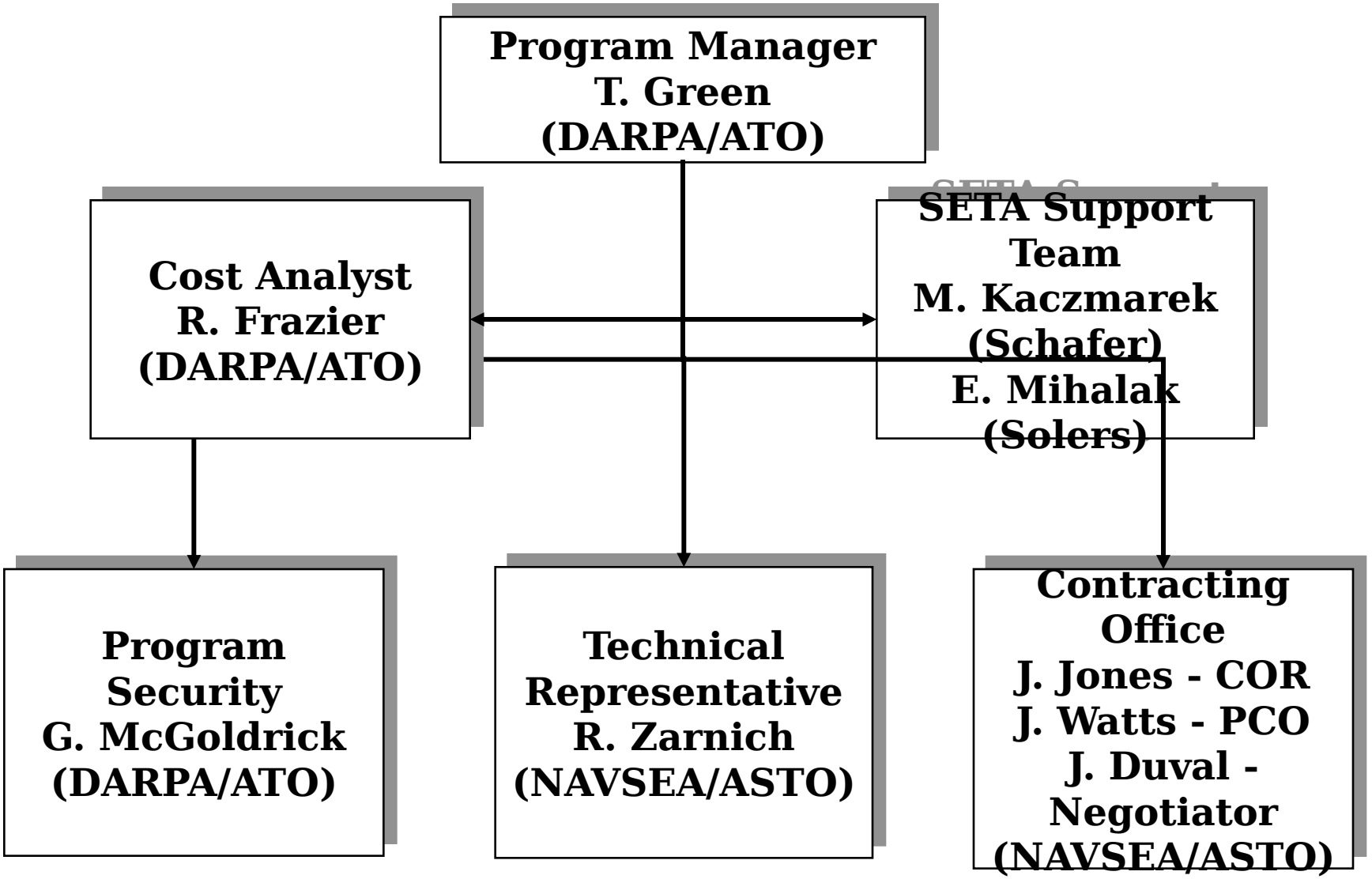
- **Tactical Signal Processing**
  - Source/receiver motion
  - Array shape compensation
  - Processing thru maneuvers
  - Array noise suppression
  - Reduced rank techniques
- **Surface Discrete Suppression**
  - Multi-path processing
  - Adaptive noise cancellation
  - Coherent multi-array processing
  - In situ calibration
- **External Information Use**
  - Sensor location/accuracy
  - Environmental data
  - Number/location of interferers
  - Sources of opportunity
- **Efficient Search Techniques**
  - Broadband signature processing
  - Information visualization and drill down
  - Operator feedback

Technology development and demonstration within an end-to-end system context

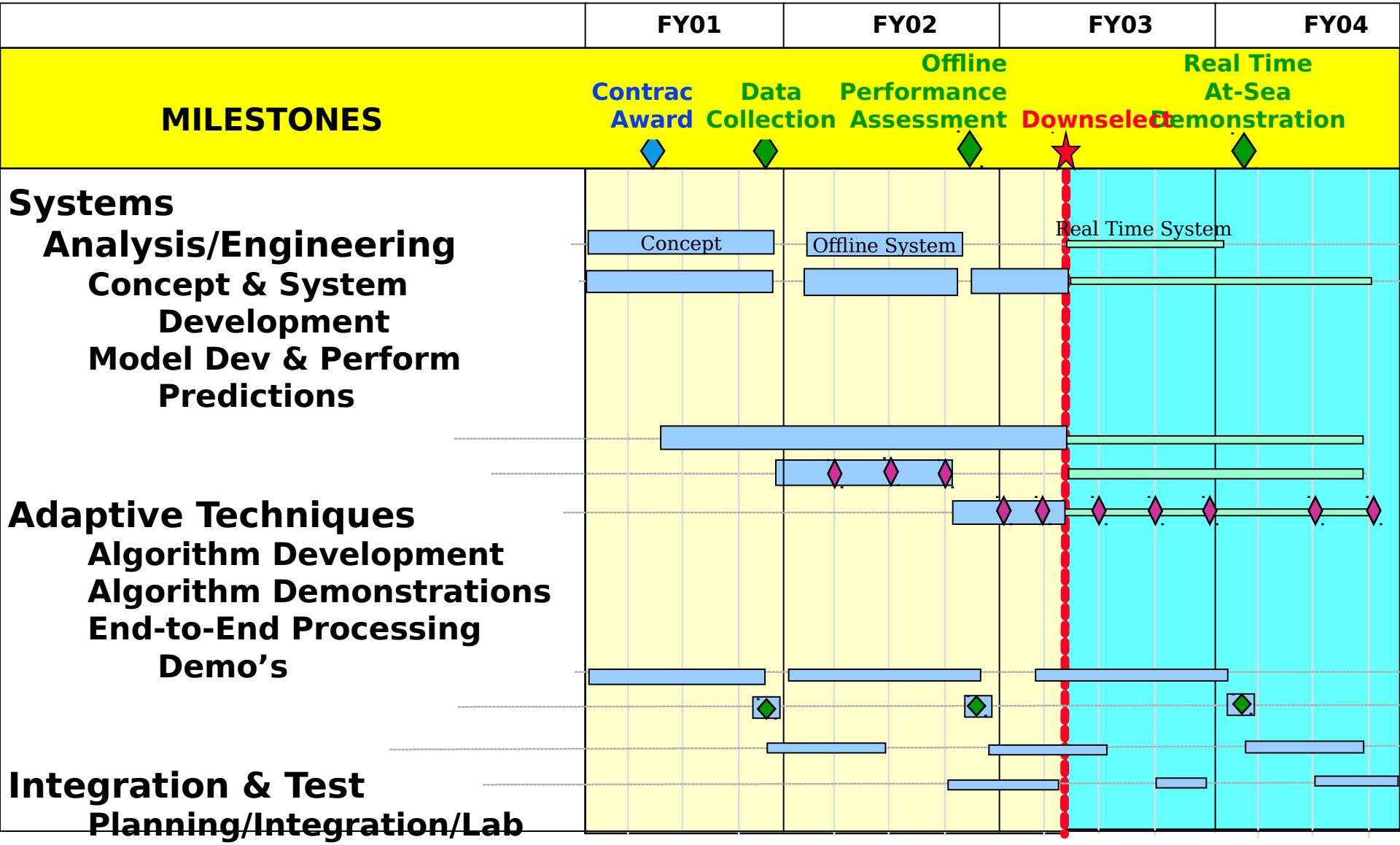
Community Interactions



Management Organization



Program Schedule



Acquisition Strategy

- **Phase 1 (Base): Two Industry teams anticipated**
  - **Development of prototype shallow-water processing system for mobile multi-line arrays**
  - **Mid-term downselect to single team for Phase 2**
- **Phase 2 (Option): One Industry team anticipated**
  - **Real-time system development and demonstration**
- **Government Team**
  - **Planning, execution and analysis of 3 at-sea experiments**
    - **Early data collection to support development and analysis**
    - **Mid-term off-line performance assessment**
    - **Real-time processing demonstration**
  - **“Red team” novel concepts, performance prediction and assessment**

Contractor Teaming

- **Strongly encouraged (though not required) to facilitate “best-in-class” solutions to the RPS challenge**
- **Team composition should emphasize algorithm innovation and system optimization rather than “EMD-like” system integration**
- **Direct RPS government team interchange with algorithm developers is expected**

Technical Priorities
(Descending Order)

- **Phase 1**
  1) **Innovative high-payoff algorithm development**
  2) **System architecture optimization**
  3) **Performance demonstration and assessment**
- **Phase 2**
  1) **Real-time prototype (vice EMD) implementation**
  2) **Refinement of architecture and algorithm design**
  3) **Information visualization and efficient search tools**
  4) **At-sea demonstration**

Exit Criteria

Phase 1

Demonstrate via Mid-Term Assessment:

- **Coherent processing of multi-line arrays**
- **Target detection and tracking**
  - **Through receiver maneuvers**
  - **In forward-sector**
- **Figure of Merit improvement**
  - **Detection: > 6 dB (goal is 10 dB)**
  - **Discrete interference rejection: > 10 dB**

Performance Assessment

Phase 1

- **Data sets**
  - **“Open” calibration data for training including available target “truth” and environmental data**
  - **Performance assessment on Open and “Closed” data**
- **Methodology**
  - **Contractor proposed and executed**
  - **Government oversight**
  - **Provides a compelling case for proposed system’s design and performance**

Key Questions
(Not Evaluation Criteria)

Things to Consider When Writing Your Proposal!

- **Who are your team members and what unique capabilities do they bring to your effort?**
- **What is your system concept and architecture trade space?**
- **What algorithms do you think you'll use?**
- **How will you predict and measure performance?**
- **What metrics will you use to characterize performance?**
- **What is your design "operating point" for the metrics used in Phase 1? For Phase 2?**
- **How will you convince us that you've achieved your stated performance?**
- **How will you integrate the system into a real-time prototype?**

RPS Industry Day Agenda

27 October 2000

0800	Introduction & Welcome	Dr. T. Green
0805	Facilities/Security	Mr. R. Dean
		Mr. G. McGoldrick
0815	RPS Goals & Technical Objectives	Dr. T. Green
0845	Procurement Process	Ms. J. Duval
0900	Advanced Processor Build	Dr. R. Zarnich
0930	ONR Technology & Plans	Dr. J. Tague
1000	Break	
1015	Operational Issues/Future Focus	CDR J. Pierse
1045	Threat Briefing	Dr. L. Parish
1115	Littoral Oceanographic Data	CDR J. White
1145	Tactical Array Systems	Dr. B. Newhall
1215	Available Data Sets	Dr. B. Newhall
1230	Adjourn	